

Drawings

Please replace Figures 1 through 10, pages 18 through 27 of the original application with drawings labeled Fig. 1 through Fig. 10 and identified in the upper right corner as "Replacement Sheet." Replacement drawings are included as an attachment to this amendment. Changes made to drawings are explained in the section titled "REMARKS – General" below.

REMARKS - General

Claims have been rewritten to more particularly define the invention in a patentable manner over the cited prior art. Specifically, claims 1 and 2 have been combined to form new independent claim 20. In claim 1, the means for removing gas has also been made narrower in scope to form new independent claim 29. Claims 20 and 29 are each followed by a series of dependent claims analogous to claims 3, 7, 8, 9, 10, 11, 12, and 13. The act of detecting a liquid has been added to claim 18 to form new independent method claim 38. In addition, the scope of this method claim has been narrowed substantially. Improper antecedent basis in claims 2, 7, and 8 has been corrected in new claims derived from these.

A controller, stepper motor, and valve actuators have been added to drawings so that all features which appear in claims also appear in drawings. Connections between the controller and valve actuators, stepper motor, and liquid detectors have also been added to drawings. Additional reference numerals have been added to drawings to better identify structure of the invention. Corresponding reference numerals have been added to the section titled "Detailed Description of the Invention" in the specification. Components cited in claims, but not previously included in the detailed description are now included so that they may be identified in drawings.

Rejection of claims under 35 U.S.C. 102(b) as being anticipated by Faure 4,189,943

Claims 1, 5, 7-8, 18-19 were rejected under 35 U.S.C. 102(b) as being anticipated by Faure 4,189,943.

Faure describes an "Apparatus for Volume Measurement of Liquids" which comprises: a cylinder and piston or variable volume chamber; a stepping motor or means for controllably adjusting the volume of the variable volume chamber; a plurality of valves; at least one conduit disposed between the variable volume chamber and at least one of the plurality of valves; and a means for removing gas from a system formed by the variable volume chamber, the plurality of valves, and the at least one conduit. The system disclosed by Faure can be operated to: remove gas from the system formed by the variable volume chamber, the plurality of valves, and the at least one conduit; and aspirate a volume of liquid into the system whereby the known volume of the system in conjunction with the complete filling of the system result in an accurate measurement of the aspirated volume of liquid. The system disclosed by Faure can also be operated to dispense the measured liquid into a container by providing a means to expel the liquid.

The means for removing gas from the system described by Faure are quite different from that of the present invention. Faure's device requires the use of a liquid immiscible with the liquid to be aspirated. This immiscible pusher liquid displaces gas from the system by filling the system as a prerequisite to aspiration of the liquid to be measured. The present invention eliminates the need for a pusher liquid or immiscible liquid. Instead, the liquid being aspirated is used to displace gas from the system. This is accomplished through the use of a passageway from the interior to the exterior of the variable volume

chamber, a valve, and an optional pump in fluid communication with the passageway. The passageway from the interior to the exterior of the variable volume chamber is distinct from the conduit through which liquid is aspirated and dispensed.

Independent claim 1 has been rewritten as new independent claim 20 to define patentably over Faure, Anscherlik, Jones et al., Keyes et al., Mathis, Shimano, Gerich, Snodgrass et al., Florian, Tisone, Liston, and Edwards, and any combination thereof. Specifically, new claim 20 adds to claim 1 "a means to detect the presence or absence of a liquid in said at least one conduit so that the precise location of said liquid in relation to said plurality of valves and said variable volume chamber may be determined."

Independent claim 1 has also been rewritten as new independent claim 29 to define patentably over Faure, Anscherlik, Jones et al., Keyes et al., Mathis, Shimano, Gerich, Snodgrass et al., Florian, Tisone, Liston, and Edwards, and any combination thereof. The change distinguishing claim 29 from prior art is the narrowing of the means for removing gas from a system. In claim 29, said means comprise "a fluid path distinct from said at least one conduit, said fluid path extending from the interior to the exterior of said variable chamber, and at least one additional valve in direct fluid communication with said fluid path."

Independent method claim 18 has been rewritten as new independent method claim 38 to define patentably over Faure, Anscherlik, Jones et al., Keyes et al., Mathis, Shimano, Gerich, Snodgrass et al., Florian, Tisone, Liston, and Edwards, and any combination thereof. The process of detecting a liquid in a conduit has been added to claim 18. In addition, substantial detail has been added to narrow the scope.

The suitability of claims 20, 29, and 38 will be discussed below.

Rejection of claims under 35 U.S.C. §103(a)

Claim 3 was rejected under 35 U.S.C. §103(a) as being unpatentable over Faure 4,189,943 in view of Jones et al. 3,901,653. Faure had taught all features of the invention in claim 3 except a controller. Jones et al. taught the use of a controller in communication with a means for controlling the volume of a variable volume chamber and a means for actuating a valve.

Claim 6 was rejected under 35 U.S.C. §103(a) as being unpatentable over Faure 4,189,943 in view of Gerich 5,127,547. Faure had taught all the means of the claimed invention except a means to create a seal between a piston and a cylinder. Gerich taught the means to create a seal between a piston and a cylinder.

Claim 3 has been rewritten as claims 21 and 30 in which a controller is in communication with either a means to detect the presence or absence of liquid or a valve in fluid communication with the distinct fluid path used to exhaust gas from the system..

Claim 6 has been withdrawn. Its subject matter is not the basis of any new claim.

Allowance of Claim 20

In the section on "Allowable Subject Matter" in the current Office Action, it is stated that claim 2 is "objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims." Claim 2 has been combined with claim 1 to form claim 20.

Novelty of Claim 29 under 35 U.S.C. 102

(1) None of the references cited disclose a means of removing gas from a fluid handling system, said means comprising a fluid path from the interior to the exterior of a variable volume chamber, said fluid path being distinct from the conduit used for aspirating and dispensing the measured liquid, and said fluid path being in fluid communication with a valve. Only Anscherlik, Jones et al., and Liston disclose a variable volume chamber having a penetration through the variable volume chamber distinct from the conduit through which fluid is either aspirated or expelled. None of these references discloses a valve in direct fluid communication with a fluid path extending from the interior to the exterior of the variable volume chamber, where said fluid path is distinct from the conduit used to aspirate or expel fluid.

(2) Anscherlik and Jones et al. use the penetration through the variable volume chamber to admit air to the variable volume chamber, not to expel it. Liston uses penetrations through the sides of syringes or variable volume chambers to supply these variable volume chambers with additional liquid, not to expel gas.

(3) Faure's means for removing gas from his apparatus comprises the same conduit used for aspiration and dispensing of liquid. Only one conduit is in fluid communication with the variable volume chamber disclosed by Faure.

Unobviousness of Claim 29 under U.S.C. 103

The novel physical features of claim 29 produce new and unexpected results and hence are not obvious and are patentable over the references cited above.

(1) The addition of a separate and distinct fluid path as a means of removing gas from the system allows the accurate aspiration and dispensing of sequential but differing volumes of the same liquid or sequential but differing volumes of different liquids. Except for the device disclosed by Faure, the devices disclosed in the cited prior art either do not remove gas from the system (Mathis), can only aspirate and dispense a constant fixed volume (e.g. Anscherlik and Jones et al.) or are suited to dispensing only a single liquid in that they require extensive cleaning, priming, and/or bleeding to change liquids. Faure's device requires the use of a pusher liquid which is immiscible with the liquid being aspirated and dispensed. No one liquid is immiscible with all other liquids. Thus,

Faure's device is limited in the range of liquids which can be dispensed without changing pusher liquids. No such limitations exist for the current invention.

(2) Faure's device requires the use of different ports for aspiration depending on whether the subject liquid is more or less dense than the pusher liquid. In the current invention, aspiration and dispensing take place through the same port regardless of density.

(3) The current invention can accurately measure volumes of liquid without the use of a pusher liquid regardless of the density or vapor pressure of the liquid.

(4) The current invention allows the variable volume chamber to be oriented so that the conduit through which aspiration and dispensing occurs is located at the lowest point of the variable volume chamber. This orientation permits the expulsion of all liquid which is aspirated into the variable volume chamber. For systems in which there is only a single penetration of the variable volume chamber, it is not possible to first remove all gas and subsequently all liquid from the variable volume chamber without changing the orientation of the variable volume chamber.

Novelty of Claim 38 under 35 U.S.C. 102

None of the references cited are capable of performing the method recited in claim 38.

(1) The devices of Anscherlik and Jones et al. are only capable of aspirating and measuring a fixed volume. Device components must be replaced in order to alter the volume to be measured.

(2) Keyes et al. employ a variable volume chamber and a means to detect the presence or absence of liquid. However, their variable volume chamber is intended to provide constant pressure. Its volume cannot be controllably adjusted. As a result, this device is not capable of aspirating a liquid. Liquid is provided to the variable volume chamber by means of a gravity feed. This device is best suited for repetitive dispensing of fixed volumes. To change the volume dispensed, one must change liquid detector locations.

(3) Faure's device is not capable of displacing liquid to a precise location in a fluid path, said location being predetermined by the position of a liquid detector.

Unobviousness of Claim 38 under U.S.C. 103

The novel method of claim 38 produces new and unexpected results and hence is not obvious and is patentable over the references cited above.

(1) Faure's is the only device cited capable of accurately measuring a range of volumes for disparate liquids without the need to interchange internal components such as volumetric flasks or the need to perform a repriming or rebleeding operation. The current

invention also has this capability. Unlike Faure's device, operation of the current invention eliminates the need for an immiscible pusher liquid to achieve accuracy.

(2) If one were to eliminate the immiscible liquid of Faure's device, one might attempt to argue that liquid detection in the current invention is superfluous and that Faure's device can be made to produce an accurate volumetric measurement following the method disclosed in claim 38 excepting liquid detection. It cannot and neither is this obvious as will be seen from the argument which follows. Assume that Faure's system is initially filled with gas and that the piston of the syringe pump is fully advanced to the syringe pump orifice. Next, place the syringe pump in fluid communication with a liquid and retract the piston a known distance until liquid enters the syringe pump. Now allow the gas to rise to the top of the syringe pump. The volume of gas in the syringe pump is not equal to the volume of gas in the system prior to aspirating the liquid because the gas pressure in the syringe pump is not the same as the initial gas pressure in the system. The weight of the liquid column pushing or pulling on the gas in the syringe pump will change the pressure of the gas in the syringe pump and hence its volume. Even if one were to align system components horizontally in an attempt to negate the effect of the weight of the column of liquid, the vapor pressure of the liquid would change the pressure of the gas and hence its volume. Because vapor pressure is highly dependent on temperature and is specific to the liquid, it would be nearly impossible to accurately predict the volume of gas in the syringe pump. Not knowing the volume of gas in the syringe pump, it would be necessary for accurate volumetric measurement to expel liquid from the syringe pump through a separate line prior to continued aspiration. The expelled liquid is process waste since its exact volume is unknown. Thus the use of a liquid detector is necessary for accurate volumetric measurement if all of the liquid aspirated is to be measured and retained.

The measurement and retention of all aspirated liquid in a volumetric measurement device which does not require a pusher liquid, interchange of internal components for measurement of different volumes, or rebleeding or repriming for the measurement of different liquids is an unexpected result.

(3) Inherent in the design of devices disclosed by Anscherlik and Jones et al. is the concept of gas pressure control to maintain the height of liquid in a column. Keyes et al. teach the use of constant pressure. Only Faure teaches the necessity for elimination of any dead space to achieve accurate results. Designs disclosed by other prior art such as Liston, Tisone, Gerich, and Snodgrass et al. implicitly assume the elimination of dead space. None of the prior art teaches the reasoning behind pressure control or the elimination of dead space. For designs which implicitly assume the elimination of dead space, one may safely assume the effect on accuracy to be the inclusion of gas in the volumetric measurement. One might argue that in light of Anscherlik and Jones et al., the effect of liquid column height on total volume of a gas-liquid system should be known to those skilled in the art, although none of the prior art explicitly teaches this effect. Because Faure does not explicitly teach the effect of vapor pressure on accuracy, one can only assume that his concern is the effect of inclusion of gas on the volumetric measurement, or at most, the influence of liquid column height on the volume of a gas-

liquid system. Thus for a system having a controllable variable volume chamber, means to track changes in the volume of the chamber, and computational means, applicants argue that those skilled in the art would attempt to expel a volume of gas equal to the initial volume of gas in the system, or at best, the initial volume of gas in the system modified to account for the weight of liquid columns. Applicants further maintain that since the prior art does not explicitly teach the effects of liquid column height and vapor pressure on the accuracy of volumetric liquid measurement, the expressed or implied need to eliminate dead space or gas from a liquid measurement system is intuitive, but not obvious.

(4) The use of a separate fluid path to exhaust gas from a variable volume chamber is counterintuitive and therefore not obvious. One skilled in the art would naturally seek to minimize the number of paths in fluid communication with the variable volume chamber in the interest of minimizing manufacturing costs. This is the approach taken by Faure and Tisone. The use of an additional independent fluid path in the variable volume chamber allows for the expulsion of either gas or liquid without the need to change the orientation of the chamber.

Dependent Claims

The subject matter of claims 9 – 13 is duplicated in claims 24 – 28 and repeated in claims 33 – 37. Claims 24 – 28 are dependent on independent base claim 20. Claims 33 – 37 are dependent on independent base claim 29. Applicants argue that because dependent claims are narrower than the claims on which they depend, if claim 20 is allowed, then claims 24 – 28 should be allowed. Likewise, if claim 29 is allowed, then claims 33 – 37 should be allowed.

Claim 3 has been rewritten as claims 21 and 30. In claim 21, communication with a liquid detector is added. In claim 30, controller communication with an exhaust valve has been added. Claim 21 is dependent on independent base claim 20. Claim 30 is dependent on independent base claim 29. Applicants argue that because dependent claims are narrower than the claims on which they depend, if claim 20 is allowed, then claim 21 should be allowed. Likewise, if claim 29 is allowed, then claim 30 should be allowed.

Claim 7 has been duplicated in claim 22 and rewritten in modified form in claim 31. Claim 8 has been duplicated in claim 23 and rewritten in modified form in claim 32. Claim 23 is dependent on claim 22 which is dependent on independent base claim 20. Claim 32 is dependent on claim 31 which is dependent on independent base claim 29. Applicants argue that because dependent claims are narrower than the claims on which they depend, if claim 20 is allowed, then claims 22 and 23 should be allowed. Likewise, if claim 29 is allowed, then claims 31 and 32 should be allowed.

New dependent claims 21 – 28 and 30 – 37 incorporate all the subject matter of independent claims 20 and 29 respectively. Therefore, these dependent claims are patentable for the same reasons as their independent parent claims. Dependent claims 21

– 28 and 30 – 37 are even more patentable because they add additional limitations as described below.

Claim 21 additionally recites a controller in communication with a means to detect the presence or absence of liquid in a conduit. This combination is not suggested by Faure. Faure's device is complete and functional in itself and would not benefit from the addition of liquid sensors.

Claim 22 discloses a valve used to control the flow of gas into or out of the variable volume chamber. Faure's device relies upon elimination of gas from the system. Aspiration of gas is counterproductive to the operation of Faure's system.

Claim 23 is dependent on claim 22 and recites structure wherein a valve is used to control the aspiration or expulsion of liquid from the variable volume chamber. Faure's device is capable of the recited liquid transfers but is not compatible with aspiration of gas as required by the base claim.

Claim 24 cites means for minimizing the free volume of the system prior to aspiration of liquid. None of the references cited refer to such means.

Claim 25 recites means to substitute liquid for gas within the system by controllably adjusting the volume of the variable volume chamber in conjunction with the operation of a valve. Faure's system is capable of this operation. Thus this claim is patentable for the same reasons as its independent parent claim, claim 20.

Claim 26 recites a means to substitute liquid for gas within the system while maintaining a constant volume. None of the references cited have this capability.

Claim 27 discloses a means to create a vacuum for the purpose of removing gas. None of the references cite the use of a vacuum.

Claim 28 cites structure for a variable volume chamber which is common to a syringe pump. Faure and most other references employ a syringe pump. Thus this claim is patentable for the same reasons as its independent parent claim, claim 20.

Claim 30 cites a controller which is in communication with a means to actuate a valve used to exhaust gas from the system. None of the references cited refer to a controller used for this purpose.

Claim 31 discloses a valve used to control the flow of gas into and out of the system. Faure's device relies upon elimination of gas from the system. Aspiration of gas is counterproductive to the operation of Faure's system.

Claim 32 is dependent on claim 31 and recites structure whereby liquid may be aspirated into or expelled from the system. Faure's device is capable of the recited liquid transfers but is not compatible with aspiration of gas as required by the base claim.

Claim 33 cites a means to minimize the free volume of the system. None of the references cited refer to such means.

Claim 34 recites a means to substitute liquid for gas within the system by controllably adjusting the volume of the variable volume chamber in conjunction with the actuation of the valve in communication with the fluid path which is distinct from the conduit. Faure's system employs no such fluid path and hence no such valve.

Claim 35 recites a means to substitute liquid for gas within the system while maintaining a constant volume. None of the references cited have this capability.

Claim 36 discloses a means to create a vacuum as a means of gas removal. None of the references cite the use of a vacuum.

Claim 37 cites structure for a variable volume chamber which is common to a syringe pump. Faure and most other references employ a syringe pump. Thus this claim is patentable for the same reasons as its independent parent claim, claim 29.

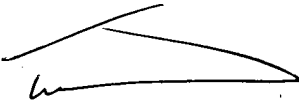
Conclusion

For all the reasons given above, applicants respectfully submit that the errors in the specification are corrected. The drawings comply with 37 CFR 1.83(a). Claims comply with 35 USC 112. Machine claims define over the prior art under Section 102 because they cite novel structure such as a liquid detector or second independent fluid path. The claimed distinctions are of patentable merit under Section 103 for the following reasons: they allow for the accurate aspiration and dispensing of sequential but differing volumes of different liquids; they allow for the accurate aspiration and dispensing of sequential but differing volumes of different liquids; they eliminate the necessity for use of a pusher liquid; they allow a single conduit to be used for aspiration of liquid regardless of density; they eliminate the effect of vapor pressure on the accuracy of volumetric measurement; they allow for expulsion of all liquid from a variable volume chamber without the need to reorient the chamber; they allow for the retention of all liquid used in the measurement process; and they employ a second fluid path. These results are not obvious and in at least one case, counterintuitive. The method claim defines over the prior art under Section 102 because it performs actions not capable of being performed by the prior art. For example, no prior art device is capable of displacing liquid to a precise location in a fluid path as determined by a detector by controllably adjusting the volume of a variable volume chamber. Among other reasons, the method claim is of patentable merit under Section 103 because the use of a separate fluid path to exhaust gas from a variable volume chamber is counterintuitive. Accordingly, applicants submit that this application is now in full condition for allowance, which action applicants respectfully solicit.

Conditional Request For Constructive Assistance

Applicants have amended the specification and claims of this application so that they are proper, definite, and define novel structure which is also unobvious. If, for any reason this application is not believed to be in full condition for allowance, applicants respectfully request the constructive assistance and suggestions of the Examiner pursuant to M.P.E.P. 2173.02 and 707.07(j) in order that the undersigned can place this application in allowable condition as soon as possible without the need for further proceedings.

Very respectfully,



Thomas M. O'Brien



C. William Merten

----- Applicants Pro Se -----

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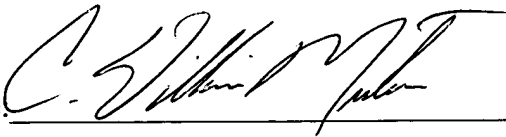
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Certificate of Mailing

I hereby certify that this correspondence, and attachments, if any, will be deposited with the United States Postal Service by First Class Mail, postage prepaid, in an envelope addressed to "Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450" on the date below.

Date: MARCH 7, 2006

Inventor's Signature: 

Appendix I to Amendment A
With Replacement Paragraphs Marked Up to Indicate Changes

Commissioner for Patents
P.O. Box 1450
Arlington, VA 22313-1450

Sir:

Pursuant to Rule 121, the following is a copy of all of the paragraphs amended by the attached Amendment A, with all changes indicated by striking through deletions and underlining additions.

DETAILED DESCRIPTION OF THE INVENTION

The first embodiment of this method and invention is a single pump system for measuring and dispensing single liquids and mixtures of liquids in precise, accurately measured volumes. This system, shown in FIG. 1, consists of a syringe pump 2, a valve manifold 4 (with multiple valves) and an air valve 6. The valve manifold contains valves 1 12 and 2 42, several supply lines or conduits 3 14, an outlet or dispensing line/nozzle or conduit 4 16, and a line or conduit leading to a syringe pump 5 18. It will become apparent that only a single supply line is required although multiple supply lines are particularly well served by this invention. The syringe pump 2 is comprised of a cylinder or cavity 6 22, piston or member 7 24, and a means to displace the piston within the cylinder such as a lead screw 26 and stepper motor (~~not shown~~) 28. The piston 24 may have at least one o-ring 8 30 partially contained inside a groove 32 around its circumference, which seals with the cylinder 22. The piston 24 may also have two o-rings or other suitable seal for improved sealing. Displacement of the piston 24 inside the cylinder 22 changes the volume of the chamber formed by the cylinder end, wall, and piston bottom. The piston contains a hollow passage or conduit 9 34 which leads from the inside of the chamber to an air valve 10 6. The piston 24 and cylinder 22 are oriented so that the mouth of the passage 34 within the piston 24 is located at the highest practical point within the variable volume chamber, thus allowing air to escape from the chamber. The outlet of the air valve is open to the atmosphere or a body of gas 11 36. Air valve liquid sensing device or detector 13 38 is located on either side of the air valve 10 6. Dispense valve liquid sensing device or detector 14 40 is located on either side of the dispense valve. All components are connected with appropriately sized tubing.

This system is specifically designed to have a minimal internal volume when the syringe piston 24 is fully inserted into the cylinder 22. This is intended to reduce the amount of air initially present in the system. The location, size, and arrangement of the internal passages of this system are such that at one specified volume (such as 10mL) the system can accurately measure the volume of a liquid regardless of that liquid's density or vapor pressure. This measured volume remains accurate regardless of which supply line 14 and valve 12 are used.

To begin the volume measurement process, the system starts with the syringe pump piston 24 at the bottom of its stroke as shown in FIG. 1. This eliminates most of the air in the system. Next, the desired supply line valve 12 is opened and the syringe piston

24 is displaced upward (away from the bottom of the cylinder 22) a known distance, as shown in FIG. 2. This movement of the syringe draws a volume of liquid 1244 into the system from the supply line 14. The supply line valve 112 is then closed and the air valve 106 leading from the syringe piston 24 is opened. The syringe piston 24 is then displaced downward, as shown in FIG. 3, forcing the liquid in the system through the tubing 34 leading to the air valve 106. Using a liquid sensing device 1338 to sense the position of the liquid, the liquid is pushed just past the air valve 106 and the valve is closed. This procedure removes the air from inside the syringe pump 2. Next, the dispense line valve 242 is opened. The syringe piston 24 is once again displaced in the downward direction, as shown in FIG. 4, pushing the liquid just past the dispense valve 242 sensing the position of the liquid using liquid sensing device 1440. The dispense valve 42e is then closed. This procedure removes the air from inside the valve manifold 4. At this point in the process there is no air in the system, only liquid. The volume of liquid is known by virtue of the position of the piston 24 in the syringe pump 2 and the known volumes of the valve manifold 4, conduits 18, and hollow passage 34. The supply line valve 112 is then opened. The syringe piston 24 is then displaced upward a known distance that will result in the intake of the desired volume of liquid 1548, as shown in FIG. 5. After the piston 24 has been displaced, the system pauses to allow any cavitation to subside. The supply valve 112 is then closed. At this stage the system contains the exact desired volume of a specified liquid. This correct volume is then expelled into an appropriate container 1650 by opening the dispense line valve 242 and displacing the syringe piston 24 fully downward, as shown in FIG. 6. The dispense line valve 242 is then closed and the air valve 106 is opened. The piston 24 is retracted upward fully, drawing in a full volume of air. The air valve 106 is then closed. The dispense line valve 242 is once again opened and the syringe piston 24 is displaced fully downward, expelling the remaining liquid. This purging process can be repeated as many times as necessary to expel any residual liquid thereby producing the required precision for volume measurement.

An alternate embodiment of this device, shown in FIG. 7, is created by adding a secondary pump 1752, another valve 1854, and another liquid sensing device or detector 1956. The initial air removal step, as shown in FIG. 8, is achieved through the use of the secondary pump 1752. This is accomplished by first opening the supply valve 112, and then opening the secondary pump valve 1856. The secondary pump 1752 is then operated until the liquid has been detected by the secondary pump liquid sensing device or detector 1956. At this point, both the supply valve 112 and secondary pump valve 1854 are closed. The remaining unwanted air is removed through the use of the main syringe pump 2 as

shown in FIG. 9. The dispense valve 242 is opened and the syringe pump piston 724 is displaced downward until the liquid is pushed past the dispense valve 242 and detected by the dispense valve liquid sensing device 1440. From this point, the volume measurement and dispense procedure are conducted in the same manner as the previous embodiment.

Another embodiment of this device is shown in FIG. 10. As with the previous embodiment, a secondary pump 1752 is added to the system. The dispensing and volume measurement procedure for this device begins with the piston 724 fully inserted into the cylinder 622. Next, secondary pump valve 1854 is opened while all other valves remain closed. Secondary pump 1752 is then activated to remove the air from the system by creating a vacuum. Once a vacuum exists in the system, secondary pump valve 1854 is then closed and secondary pump 1752 is deactivated. With the system still under vacuum, supply valve 112 is opened, filling the system with liquid. From this point, the volume measurement and dispense procedure are conducted in the same manner as the first embodiment.

Those skilled in the art will appreciate that various adaptations and modifications of the just-described preferred embodiments can be configured without departing from the scope and spirit of the invention. For example, operations may be performed in a different order to achieve an identical result or the hollow passage located in the piston might be located in the cylinder wall instead. Therefore, it is to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described herein.

Appendix II to Amendment A
Replacement Drawings

Commissioner for Patents
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Sir:

Pursuant to Rule 121, the following attachment contains drawings labeled Fig. 1 through Fig. 10 and bearing the identification "Replacement Sheet." The drawings in this attachment replace drawings identified Fig. 1 through Fig. 10 in the original application.